Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application.

1. (Currently amended) A method for performing a single-qubit gate on the state of a data qubit, the method comprising:

setting an ancillary qubit to a predetermined initial state $|I\rangle$;

coupling said data qubit and said ancillary qubit for a first period of time to apply said single-qubit gate to said data qubit; and

measuring a state of said ancillary qubit, thereby collapsing the quantum state of the ancillary qubit to a classical result $|0\rangle$ or $|1\rangle$, and wherein the classical result, $|0\rangle$ or $|1\rangle$, indicates whether said single-qubit gate has been applied to said data qubit.

2. (Cancelled)

3. (Currently amended) The method of claim 1, wherein, when said measuring indicates that said single-qubit gate was not successfully applied to said data qubit ~~performed~~, the method further ~~comprising~~ comprises coupling said data qubit and said ancillary qubit for a second period of time.

4. (Original) The method of claim 1, wherein said predetermined initial state $|I\rangle$ comprises a superposition of basis states of said ancillary qubit.

5. (Original) The method of claim 4, wherein said predetermined initial state has the form

$$|I\rangle = \frac{a|0\rangle + b|1\rangle}{\sqrt{2}},$$

wherein,

$|0\rangle$ is a first basis state for said ancillary qubit;

$|1\rangle$ is a second basis state for said ancillary qubit;

a is a first probability amplitude;

b is a second probability amplitude; and

the magnitude of a and b are about the same.

6. (Original) The method of claim 5, wherein said predetermined initial state is obtained by applying a single-qubit Pauli X gate for a phase $\pi/2$ to said ancillary qubit for a predetermined period of time.

7. (Original) The method of claim 6, wherein said predetermined period of time is about

$$\frac{h}{\Delta}\frac{\pi}{2},$$

wherein h is Planck's constant and Δ is the tunneling amplitude of said ancillary qubit.

8. (Original) The method of claim 1, wherein said data qubit is a superconducting qubit.

9. (Original) The method of claim 8, wherein said superconducting qubit is a superconducting phase qubit.

10. (Original) The method of claim 9, wherein said superconducting phase qubit is comprised of an unconventional superconducting material.

11. (Original) The method of claim 9, wherein said superconducting phase qubit is a permanent readout superconducting qubit or a two-junction flux qubit.

12. (Original) The method of claim 8, wherein the superconducting qubit is a superconducting charge qubit.

13. (Original) The method of claim 1, wherein said coupling of said data qubit and said ancillary qubit for a first period of time comprises applying a Josephson gate between said data qubit and said ancillary qubit.

14. (Original) The method of claim 1, wherein said single-qubit gate is a single-qubit Pauli Z gate.

15. (Original) The method of claim 1, wherein said first period of time is about

$$\frac{h}{J_1} \cdot \frac{\pi}{2},$$

wherein,

J_1 is a coupling term between said ancillary qubit and said data qubit during said coupling; and

h is Planck's constant.

16. (Original) The method of claim 3, wherein said second period of time is about

$$\frac{h}{J_2} \cdot \pi$$

wherein,

J_2 is a coupling term between said ancillary qubit and said data qubit during said second coupling; and

h is Planck's constant.

17. (Original) The method of claim 3, wherein said second time period is about equal to said first time period and wherein a coupling term between said ancillary qubit and said data qubit during said first coupling is about double a coupling term between said ancillary qubit and said data qubit during said second coupling.

18. (Original) The method of claim 1, wherein said coupling of said data qubit and said ancillary qubit for said first period of time comprises an XX gate.

19. (Original) The method of claim 1, wherein said single-qubit gate is an X gate or a bit-flip gate.

20. (Original) The method of claim 1, wherein said coupling of said data qubit and said ancillary qubit is a YY gate.

21. (Original) The method of claim 1, wherein said single-qubit gate is a Y gate.

22. (Currently amended) A method for applying a single-qubit gate to an arbitrary quantum state, wherein said arbitrary quantum state is initially on a data qubit, the method comprising:

setting a state of a first and second ancillary qubit to an entangled initial state $|I\rangle$;

weakly measuring a state of said data qubit and said first ancillary qubit thereby performing ~~a~~ said single qubit ~~operation~~ gate on said arbitrary quantum state with a probability; and

determining a first result from said weakly measuring step.

23. (Currently amended) The method of claim 22, wherein said arbitrary quantum state is present on said second ancillary qubit after said weakly measuring step and said first result indicates that said single-qubit gate has been applied to said arbitrary quantum state.

24. (Currently amended) The method of claim 22, wherein said arbitrary quantum state is present on said second ancillary qubit after said weakly measuring step and said first result indicates that said single-qubit gate was not applied on said second ancillary qubit, the method further comprising:

applying a first correction, wherein said first correction comprises weakly measuring the state of said data qubit and said first ancillary qubit; and

determining a second result.

25. (Currently amended) The method of claim 24, wherein said second result indicates that said first correction applied the Hermitian conjugate of said single-qubit gate on said arbitrary quantum state that is present on said second ancillary qubit after said ~~measuring~~ first correction.

26. (Original) The method of claim 25, the method further comprising correcting the state of said second ancillary qubit for said Hermitian conjugate of said single-qubit gate.

27. (Original) The method of claim 26, wherein correcting the state of said second ancillary qubit for said Hermitian conjugate of said single-qubit gate comprises coupling

said first ancillary qubit and said second ancillary qubit with an exchange two-qubit unitary operator:

$$U^{EX}{}_{3,2}(\pi/2,0).$$

28. (Currently amended) The method of claim 24, wherein, when said second result indicates that the Hermitian conjugate of said single-qubit gate was not applied on said arbitrary quantum state, now present on said second ancillary qubit, the method further comprises:

applying a second correction, wherein said second correction comprises weakly measuring the state of said first ancillary qubit and said second ancillary qubit; and

determining a third result.

29. (Original) The method of claim 28, wherein said arbitrary quantum state is present on said data qubit after applying said second correction and said third result indicates that said single-qubit gate was applied on said arbitrary quantum state.

30. (Original) The method of claim 28, wherein said arbitrary quantum state is present on said data qubit after applying said second correction and said third result indicates that the Hermitian conjugate of said single-qubit gate was applied on said arbitrary quantum state.

31. (Currently amended) The method of claim 30, ~~wherein the state of said data qubit is corrected~~ the method further comprising correcting the state of said data qubit for said Hermitian conjugate of said single-qubit gate.

32. (Currently amended) The method of claim 31, wherein the correction for said Hermitian conjugate of said single-qubit ~~operation~~ gate comprises coupling said data qubit and said first ancillary qubit via an exchange two-qubit unitary operator:

$$U^{EX}{}_{3,2}(\pi/2,0).$$

33. (Original) The method of claim 22, wherein said entangled initial state comprises a superposition of basis states of said first ancillary qubit and said second ancillary qubit.

34. (Original) The method of claim 33, wherein said initial state $|I\rangle$ has the form:

$$| I \rangle \approx \frac{1}{\sqrt{2}} \left(a | 01 \rangle - ib | 10 \rangle \right),$$

wherein,

$|01\rangle$ is a first state for said first ancillary qubit and said second ancillary qubit;

$|10\rangle$ is a second state for said first ancillary qubit and said second ancillary qubit;

a is a first probability amplitude;

b is a second probability amplitude;

the magnitude of a and b are about the same; and

$i = \sqrt{-1}$.

35. (Original) The method of claim 34, wherein said setting said state of said first ancillary qubit and said state of said second ancillary qubit to said entangled initial state $|I\rangle$ comprises:

a first coupling of said first and second ancillary qubits for a duration t_I;

measuring the state of at least one of said first and second ancillary qubits; and

a second coupling of said first and second ancillary qubits for a second duration t_β.

36. (Original) The method of claim 35, wherein said first coupling allows the entangled state of said first and second ancillary qubits to relax to their respective ground states.

37. (Original) The method of claim 36, wherein said duration t_i is one microsecond or less.

38. (Original) The method of claim 35, wherein said measuring results in an overall state of either $|10\rangle$ or $|01\rangle$.

39. (Original) The method of claim 35, wherein said second coupling creates a phase difference that is about π radians between the respective basis states of the entangled pair wherein the overall entangled state satisfies $|I\rangle$.

40. (Currently amended) The method of claim 35, wherein said second duration t_β is about

$$\frac{h}{J^{\alpha}} \cdot \frac{\pi}{8}$$

wherein J^{α} is a coupling term of an exchange Hamiltonian H^{ex} between ~~the data qubit and~~ the first ancillary qubit <u>and the second ancillary qubit</u> and h is Planck's constant.

41. (Original) The method of claim 35, wherein said second duration t_{β} is one microsecond or less.

42 – 43. (Cancelled)

44. (Original) The method of claim 22, wherein said data qubit is a superconducting qubit.

45. (Original) The method of claim 44, wherein said superconducting qubit is a superconducting phase qubit.

46. (Original) The method of claim 45, wherein said superconducting phase qubit is comprised of an unconventional superconducting material.

47. (Original) The method of claim 45, wherein said superconducting phase qubit is a permanent readout superconducting qubit or a two junction flux qubit.

48. (Original) The method of claim 44, wherein said superconducting qubit is a superconducting charge qubit.

49. (Original) The method of claim 22, wherein said data qubit is a quantum dot, a donor atom in silicon, a photon, a resonant cavity, an atom, or an electron.

50. (Original) The method of claim 22, wherein said first and second ancillary qubits are of the same type of qubit as said data qubit.

51. (Currently amended) The method of claim 22, wherein said first and second ancillary qubits are not the same type of qubit as said data qubit ~~of different types~~.

52. (Original) The method of claim 22, wherein said single-qubit gate is a Z gate, a phase gate, an X gate, a bit-flip gate, or a Y gate.

53. (Currently amended) The method of claim 52, further comprising creating a universal set of gates using a plurality of applications of said single qubit gate in order to create a plurality of composite gates that form said universal set of gates.

54. (Currently amended) A method for applying a single-qubit gate to an arbitrary quantum state that is initially present on a data qubit, the method comprising:

setting a state of a first and second ancillary qubit to an entangled initial state $|I\rangle$;

performing a weak measurement on a state of said data qubit and said first ancillary qubit ~~thereby performing a single-qubit operation as well as causing said arbitrary quantum state present on said data qubit to become present on said second ancillary qubit~~;

determining whether said weak measurement indicates said data qubit and said first ancillary qubit were in a singlet or triplet state; wherein

when the data qubit and said first ancillary qubit are in the singlet state, said single-qubit gate was applied on said arbitrary quantum state ~~that is present on said second ancillary qubit after said performing~~, and

when the data qubit and said first ancillary qubit are in the triplet state, the Hermitian conjugate of said single-qubit gate was applied on said arbitrary quantum state ~~that is present on said second ancillary qubit after said performing~~; and

performing a corrective operation when the data qubit and said first ancillary qubit are in the triplet state to convert the Hermitian conjugate of said single-qubit gate to said single-qubit gate.